DOCUMENT RESUME

ED 091 248 SE 017 956

AUTHOR Martikean, Alexandria
TITLE The Levels of Questioning and Their Effects Upon Student Performance Above the Knowledge Level of Bloom's Taxonomy of Educational Objectives. A Research Paper.
PUB DATE Jul 73
NOTE 63p.; Submitted in fulfillment of the requirements for Field Research and Development Study-E585, Indiana University Northwest

EDRS PRICE MF-$0.75 HC-$3.15 PLUS POSTAGE
DESCRIPTORS Botany; Cognitive Development; *Critical Thinking; *Educational Research; *Elementary School Science; Elementary School Students; *Questioning Techniques; *Teacher Behavior
IDENTIFIERS Bloom (BS); Research Reports

ABSTRACT

Reported is an investigation of the effects on student performance above the knowledge level (Bloom's taxonomy) as influenced by the use of teacher's questioning strategies. Two parallel forms of an elementary science unit on plants and seeds were constructed. In form A, most of the teacher questions were low level in terms of cognitive thinking; in form B, teacher questions required pupil responses above the cognitive memory level. A randomly selected group of 30 third- and fourth-grade pupils was divided into two groups of 15. The control group was taught by a teacher using form A while the investigator taught the experimental group, using form B. Pupils were pre- and posttested with the paper and pencil test reflecting the six levels of Bloom's Taxonomy of Educational Objectives. Test scores were analyzed, using t-test techniques. No statistically significant differences were found. Intragroup scores and percent of points received by each group for each test item on the pre- and posttests were also analyzed. The investigator hypothesized that her lack of significant results may have been influenced by the stage of cognitive development of the children participating in the study. The children were at the concrete operational stage. Critical thinking may not be successfully stimulated by teacher questions until children reach the formal operational state of Piaget's schemata. This hypothesis warrants further investigation. (Author/PEB)

ED 091248

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

A Research Paper

in

The Levels of Questioning and Their Effects Upon Student Performance Above the Knowledge Level of Bloom's Taxonomy of Educational Objectives

by

Alexandria Martikean

Submitted in fulfillment of the requirements for
Field Research and Development Study - E585
in the Division of Education
Indiana University Northwest
July, 1973

Approved: 7 11 1973
Month, Day, Year

By: Dr. Larry Guthrie
Research Advisor

SE 017 950

To my husband . . .

TABLE OF CONTENTS

Chapter — Page

I. THE STUDY
Significance of the Study 1
Review of the Literature 2
Limitations of the Study 4

II. DESIGN AND LIMITATION
Design of the Study 6
Proposed Methods of Collecting Data 41

III. FINDINGS
Comparison of Means 46
Item Analysis 46

IV. INTERPRETATION OF FINDINGS
Conclusion 51
Summary 54

BIBLIOGRAPHY 57

APPENDIX
Appendix A: Raw Test Scores for Pre-Test 58
Appendix B: Raw Test Scores for Post-Test 59

LIST OF TABLES

Table | Page

1. Results of Significance Test for Pre- and Post-Tests and Change in Means 46

2. Percent Change of Intragroup Scores 47

CHAPTER I

THE STUDY

Significance Of The Study

Great emphasis in public education, today, is based upon the development of critical thinking skills. The advent of the twentieth century has ushered in a vast diversity of knowledge, and the obsolescence of a major portion of this knowledge. Many things learned in the way of specifics for permanent retention by a child in today's elementary classroom will probably be out of date before he reaches the twelfth grade. Our recent space explorations has brought about new physical knowledge of our universe; recent political and social developments have resulted in the emergence of new nations and changing political boundaries.

It would seem that the major thrust in today's curriculum, in coping with the "explosion" of knowledge, is through the development of skills necessary for effective living in our complex society. Major emphasis is being placed upon the development of instructional strategies which stress the application of appropriate cognitive skills. The concern with thinking and the cognitive skills is shared by many leading curriculum developers. Hilda Taba states:

> ...recent studies of learning and experimentation with curriculum have greatly extended the scope of responsibilities of the schools. For example, the current emphasis on creativity, on autonomy of thinking, and on the method of inquiry represents a renewed concern with thinking and cognitive skills. The development of cognitive powers now is recognized as an important aspect of excellence. This extension of objectives beyond the mastery of knowledge requires

as to reexcending learning experiences. We no longer can assume that mastering well-organized knowledge automatically develops either autonomous or creative minds. (9, p. 2.)

If the major thrust in education is the development of critical thinking skills, it would seem that one of the most effective instruments for stimulating and guiding this process is the question. Thus, the purpose of the study was an attempt in exploring the significance of the types of questions asked by the teacher in setting the tone of cognition within the classroom, and its relationship to how well children are able to perform at cognitive levels above the stage of mere recall as defined by Bloom's Taxonomy of Educational Objectives.

Review of the Literature

The question is an indispensable tool of the classroom teacher. "Yet is the potential of the question being fully exploited? Although they have the capability of initiating critical and creative thinking, many questions focus upon memory of specific facts." (3, p. 657.) Research examining the kinds of questions asked in the teaching-learning process indicates that teachers place a predominant emphasis upon asking questions which search out a knowledge of facts and the recall of texbook information.

A study conducted by Doak (5, p. 178.) attempted to categorize the cognitive levels of verbal behavior of teachers and students. Doak found that teaching in the subject areas appeared to be directed at the communication of knowledge. Verbal interchanges initiated by the teacher were of the what, how, when, where variety which elicited the recall of information responses. In addition, the study showed that the teachers verbal behavior con-

trolled to some degree the level of thinking reflected by the pupils responses. Doak concluded that the teacher plays an important role in determining the level at which classroom interaction occurs.

Similar studies have been conducted concerning the relationship between the kinds of questions used in a teaching strategy and its affect upon thinking skills developed by children. Cunningham reports:

> A study by Taba, Levine, and Elzey found an almost perfect correlation between the levels of thought pupils display in their answers to teachers' questions and the types of questions asked by their teachers. In addition, the study showed that questions asked by the teacher have a very strong influence on other behaviors performed by the pupils. The way you ask questions can be one of the most influential parts of teaching. (4, p. 85.)

Hunkins conducted a study which sought to determine whether social-studies text-type materials based upon analytical and evaluative types of questions would effectively stimulate the development of critical thinking of sixth-grade pupils. From the findings, he concluded that there was no significant difference between students who were given questions with a dominant emphasis on analysis and evaluation from those students who were given questions predominantly based on the knowledge type. However, it is interesting to note that the teacher served only as a coordinator in the use of the social studies materials. Hunkins concluded:

> The restriction of pupils to answering questions with no opportunity for discussion may have tended to reduce their enthusiasm and to stifle their development of critical thinking. Discussion of the materials and the questions by teachers and pupils possibly would

> have contributed to greater and perhaps significant differences between the two treatment groups. Critical thinking would seem to demand that pupils be given the opportunity to reflect, to discuss, and to question further. The absence of this opportunity may very well have served as a deterrent to the pupils' development of critical thinking. Too, pupils might have been affected adversely because of lack of teacher interaction. (7, p. 703.)

Thus, "In the setting of the classroom, questions posed by teachers and children are foremost among the stimuli which trigger thinking and thus set the tone of cognition." (3, p. 657.)

Sanders has developed a taxonomy of questions which he believes suggests the following hypothesis for educational research, "Students who have more practice with intellectual skills will develop them to a greater degree than those who have less practice." (8, p. 6.)

The study undertaken was an attempt to expand some of the areas previously investigated and to further explore Sanders' hypothesis.

Limitations of the Study

It would seem that, from the review of literature, a project which sought to determine the relationship between the dominant use of question-strategies by the teacher above the knowledge level and its influence upon student performance at higher cognitive levels of Bloom's Taxonomy of Educational Objectives, to be a significant course for further research; however, Hunkins warns:

> At the outset, critical thinking must be seen as a vague concept; its common use frequently suggests that it is a slogan rather than a precisely formulated idea. The lack of instruments to mea-

> sure this type of thinking testifies to the difficulty of bringing adequate definition to the concept. (7, p. 703.)

It would seem that formal testing based upon standardized tests or teacher made tests may not be a suitable or adequate instrument to assess critical thinking skills. Consequently, failure of high level questions to influence student performance at high cognitive levels of Bloom's Taxonomy of Educational Objectives may be attributed to a faulty measurement instrument rather than to the questions used during the course of instruction.

The length of instructional time, for the experimental group, may not be sufficient to stimulate and foster complex cognitive functions, particularly if the children have had little experience in responding to questions which ask them to manipulate information beyond the level of recall.

Lack of teacher experience in developing a proficiency in utilizing thought-provoking reasoning questions may affect the data and results.

The underlying hypothesis of the study was not restricted to certain types of students, grade levels, or subject matter; however, the study itself dealt specifically with a given unit of study and population.

CHAPTER II

DESIGN AND LIMITATION

Design of the Study

The first step in the development of the study was the construction of two forms, A and B, of a science unit dealing with plants and seeds.

In form A, instructional techniques were based predominantly upon the use of questioning strategies requiring cognitive memory type responses from the pupils, i.e., most of the questions asked by the teacher were low on the cognitive-emphasis scale. In form B, instructional techniques were based predominantly upon the use of questioning strategies requiring responses from the pupils above the cognitive memory level, i.e., most of the questions asked by the teacher were high on the cognitive-emphasis scale.

A randomly selected population of thirty third and fourth grade pupils at Lew Wallace Elementary School in Hammond, Indiana was divided into two groups of fifteen. The control group was handled by a cooperating teacher using Form A of the science unit. The writer handled the experimental group using form B of the science unit.

Prior to instruction, a paper and pencil pre-test was administered to both groups. The test questions reflected the six levels of Bloom's Taxonomy of Educational Objectives. Scoring of the tests was conducted after the study was completed. (page 41)

A parallel post-test reflecting the six levels of Bloom's Taxonomy of Educational Objectives was given to each group upon completion of their instructional unit of study. Scoring of the tests was conducted after the study was completed for both groups.

The statistical basis for testing the hypothesis was based upon applying a t-test to test scores (pre- and post-tests respectively) to determine the significance of differences between the two treatment groups prior to instruction and after instruction.

The basic generalizations covered by both groups in the science unit were:

A. Plants that grow from seeds need proper conditions for germination.

B. For proper growth, green plants need light, proper temperature, and water.

C. Several parts of a plant function in special ways to keep the plant alive and growing.

The behavorial objectives for the control group using form A were as follows:

Knowledge

1. Given a diagram of a lima bean seed, the child should be able to correctly label each of its three parts.

2. Given pencil and paper, the child should be able to list at least three conditions necessary for seed germination.

3. Given three growth rate charts showing the effects of improper watering and temperature to lima bean germination and the interpretation for any one of the three charts. The level of acceptable performance is being able to approximate as closely as possible the given interpretation.

4. Given two growth rate charts, one showing the growth rate of a lima bean seed given too much water, and the other chart showing

the normal growth rate of a lima bean seed, drawing paper and pencil, the child should be able to correctly reproduce one of the two charts.

5. Given a diagram of a lima bean plant, the student should be able to color in those parts which supply food for the plant emeryo.

6. Given several seeds of various sizes and planting depths, the student should be able to correctly match all the seeds in decending order with the depth for planting.

7. Given pencil and paper, the student should be able to list three conditions necessary for proper plant growth.

8. Given a series of lima bean plants being grown under various conditions and a chart listing improper conditions for plant growth, the student should be able to select only those plants which demonstrate the improper conditions for plant growth.

9. Given pencil and paper, the student should be able to correctly match the parts of a plant to its particular function.

10. Given the procedure in making a colored stalk of celery, the student should be able to reproduce the procedure by making a colored stalk of celery in a color of his choice.

11. Given a diagram of a plant, the student should be able to correctly label each part.

12. Given pencil and paper, the student should be able to correctly describe a given procedure for transplanting a lima bean plant from one container to another.

The behavorial objectives for the experimental group using form B

were as follows:

Analysis

1. Given the opportunity to examine the structure of several dicotyledonous seeds (except the lima bean seed), the student should be able to infer the structure of the lima bean seed by drawing and labeling what he infers its structure to be.

Synthesis

2. Given access to materials, the student should be able to design a plan for experimentation which will test the effects of varying the conditions of water, air, temperature, and soil upon seed germination of a lima bean.

Synthesis

3. Given unorganized data on the growth rate of a radish seedling, consisting of the amount of water, temperature and the kind of soil given, the student should be able to produce a bar graph showing the seedling's probable growth rate.

Evaluation

4. Given a bar graph produced by the student in objective three, and a bar graph showing the normal growth rate of a radish seed, the student should be able to justify two causes for their differences.

Evaluation

5. Given the hypothesis that lima bean seeds can sprout without soil, the student should be able to appraise the extent to which the hypothesis maybe true by justifying his opinion through experimentation.

Evaluation

6. Given pencil and paper, the student should be able to describe at least three different kinds of information which he feels would be important to know if planting an avocado seed, and explain why he feels the information is important.

Analysis

7. Given a list of procedures for conducting an experiment to test the effect of varying a plants water supply, or amount of light given, or temperature, the student should be able to correctly identify those procedures which would not be relevant for conducting the given experiment.

Evaluation

8. Given the hypothesis that in order to grow well, green plant need the proper amount of water, light and temperature, the student should be able to plan and construct experiments which would contrast proper conditions from its corresponding improper condiction.

Application

9. Given a lima bean plant, the student should be able to successfully transplant it to another container, success will be determined if the plant continues to grow well in the new container.

Synthesis

10. Given a white carnation, the student should be able to produce a two colored carnation.

Evaluation

11. Given a picture of a water lily plant, the student should be able to predict the probable location of stomata and justify his pre-

diction in two or more complete sentences.

Evaluation

12. Given the opportunity to plant a garden outside the school, the student should be able to select a location which he thinks is the best place for plant growth and justify why he thinks it is the best location by stating at least three reasons for his selection.

The following was the science unit, form A, presented to the control group.

Generalization A: Plants that grow from seeds need proper conditions for germination.

Teaching Strategy

Discuss with the children if they have ever observed their parents or other people start a flower garden or new lawn.

Questions - Cognitive-Memory

1. What did they plant?
2. What time of the year did they plant?
3. Where did they plant their garden?

Teaching Strategy

Display a labeled picture of a lima bean seed; point out the seed coating, plant embryo and plant food. Give each child a lima bean seed; instruct the children to identify the three parts. Give each child a sheet of drawing paper and instruct the children to draw a picture of a lima bean seed and label its three parts so that it matches the displayed picture. As the child finishes his drawing, point to each labeled part and have the child state its name.

Question - Cognitive-Memory

What are the three parts of a lima bean seed?

Teaching Strategy

Display a chart listing the conditions necessary for seed germination. Instruct the children to read the chart aloud. Present to the children containers of planted lima bean seeds. One seed may be planted in very watery soil, another seed planted in some very dry soil, and a seed planted in gravel. Also display identified containers of lima bean seeds being grown in the refrigerator, on top of a heat register, and in a glass jar with very little air.

Questions - Cognitive-Memory

1. Looking at the chart, what is wrong with the way each of these lima bean seeds were planted?
2. Which statement on the chart tells you the right way to plant the seed? (Ask this question as you point to each container.)

Teaching Strategy

Give each child a lima bean seed and a container of soil. Have the children plant their seeds according to the proper conditions stated on the chart.

Question - Cognitive-Memory

What are the proper conditions necessary for seed germination?

Teaching Strategy

Present to the children several lima bean seeds germinating on a wet paper towel. Tell the children that seeds do not need soil to sprout because they get their food from the seed. Point to the shriveling seed halves, tell the children that the seed halves are shriveling

because the plant embryo is using up the food in the seed. After the above demonstration, give the children some wet paper toweling and lima bean seeds and have them repeat the demonstration.

Question - Cognitive-Memory

Can your lima bean seeds sprout without soil? Why?

Teaching Strategy

Display gardening books, filmstrips, and other materials dealing with plants. Instruct the children to select examples from the materials which demonstrate proper conditions for planting seeds and/or improper conditions for planting seeds. The children may draw one or two pictures illustrating the examples they have chosen.

Question - Cognitive-Memory

What does your picture illustrate?

Teaching Strategy

Display several identified growth rate charts showing the effects of too little water, no soil and cold temperatures on seed germination and growth. Next to these charts, show a growth rate chart for normal seed growth. Explain the meaning of the charts and how to read them.

Questions - Cognitive-Memory

1. Which chart shows proper plant growth?
2. What conditions are necessary for proper plant growth?
3. Which chart shows what happens to plant growth when not enough water is given to the plant?
4. Which chart shows what happens when the plant uses up all its food in the seed and doesn't have soil to grow?
5. Which chart shows what happens to plant growth when the tempera-

ture is too cold?

Teaching Strategy

Give the children drawing paper and instruct them to copy one of the growth rate charts and label his chart according to the given example.

Question - Cognitive-Memory

What does your chart show?

Teaching Strategy

Ask the children to describe a frisky dog.

Questions - Cognitive-Memory

1. Where does a dog get its energy?
2. Where do people get energy?

Teaching Strategy

Display a diagram of a lima bean seed.

Questions - Cognitive-Memory

1. Where does a plant embryo get its food to sprout?
2. From our observations in germinating seeds on wet paper towels, do seeds really need soil to sprout? Why?
3. What happened to our seeds on the wet paper towels after a while?
4. What did the shriveling seed halves tell you?

Teaching Strategy

Display six lima bean seedlings, one pair with both cotyledons missing, one pair with one cotyledon missing and the last pair with the plant embryo missing. Tell the children that the plant embryo is the part of the seed that grows.

Questions - Cognitive-Memory

1. Which group of seeds show a missing plant embryo?

2. Which group of seeds show half of the plant food missing?

3. Which group of seeds show no food for the plant embryo?

4. Which pair of seeds have the most food?

5. Which of these pairs show a plant embryo that will not grow on a wet paper towel? Why?

Teaching Strategy

Place the above seedlings under an inverted cardboard box. Tell the children that this procedure is to prevent the sun from helping the seeds to grow. Have the children observe daily progress of seed growth, and keep the seeds moist.

Questions - Cognitive-Memory

1. Which pair of seeds show the most growth?

2. Which pair show the least growth? Why?

Teaching Strategy

Give the children a sheet of drawing paper and instruct them to draw a picture of a lima bean seed . Instruct the children to color in the areas which supply the plant embryo with food.

Teaching Strategy

Display some radish seeds next to some lima bean seeds. Emphasize how much smaller the radish seeds are in comparison to the lima bean seeds.

Questions - Cognitive-Memory

1. Where does a plant embryo get its food to sprout?

2. Which group of seeds contain the most food for the plant embryo?

Teaching Strategy

Tell the children that the depth of planting a seed is related to the

size of the seed. Tell the children that smaller seeds require shallow planting because they contain just enough food to help the plant embryo reach the surface. Instruct the children to read the planting depths given on several seed packages. Instruct the children the arrange the seeds inside the seed packages in decending order with the given depth for planting. The children may plant the given seeds in containers of soil according to the depths recommended on the seed packages.

Questions - Cognitive-Memory

1. What are the names of the seeds you are planting?
2. How deep should you plant your seeds?
3. Which group of seeds will be planted less than one inch deep?
4. Which group of seeds will be planted one inch deep?

Generalization B: To grow well, green plants need water, light and the proper temperature.

Teaching Strategy

Display a chart showing the conditions necessary for seed germination and conditions necessary for continued plant growth. Instruct the children to read the charts orally. Tell the children that in order for plants to stay healthy, they continue to need the right amount of water, light and temperature. Next to the charts, display several young lima bean plants. Each of the lima bean plants should be in a container which is marked according to the improper condition the plant is being grown. Instruct the children to describe each plant according to the described conditions given on the containers. Instruct the children to match each improper condition they describe

with the corresponding proper condition found on the chart.

Questions - Cognitive-Memory

1. What happens to a plant given too much water?
2. What happens to a plant not given enough water?
3. What happens to a plant grown under cold temperatures?
4. What happens to a plant when it gets too much light?
5. What are the proper conditions necessary for maintaining a healthy plant?

Teaching strategy

Instruct the children to continue growing the young lima bean plants according to the improper condition marked on each container.

Generalization C: Several parts of a plant function in several ways to keep the plant alive and growing.

Teaching Strategy

Display a labeled diagram of a lima bean plant. Instruct the children to orally state each part of the plant as you point to its name. Give each child a sheet of drawing paper and instruct them to recopy the given chart, correctly labeling the three parts of the plant.

Question - Cognitive-Memory

What are the three parts of a lima bean plant?

Teaching Strategy

Instruct the children to examine the root of a lima bean seedling under a magnifying glass. Identify for the children the tap root and root hairs. Tell the children that plants absorb water through their root system; the more root hairs a plant has, the more water it can get. Tell the children, also, that when one transplants a plant

from one area to another, one needs to be careful so as not to damage the plant's root system. When one severely damages the root system of a plant, the plant is unable to get the water it needs to stay healthy.

Question - Convergent

Why should should gardeners be careful when they dig up plants and replant them in another location?

Teaching Strategy

Show the children how to transplant a lima bean plant with minimum damage to the root system. Give each child a lima bean plant and instruct them to transplant their plant to a different container. During this activity, stress to the children the procedure that was shown to them.

Teaching Strategy

Display a stalk of celery in some colored water. Show the children how the colored water travels up the stem to the celery leaves. Instruct the children to examine the colored fibers of the celery stem. Tell the children that the stem of a plant transports water from the roots to the leaves. Give each child a stalk of celery and instruct them to make their own colored celery stalk by using the food coloring of their choice.

Question - Cognitive-Memory

What is the function of the stem of a plant?

Question - Convergent

How do you make a colored stalk of celery?

Teaching Strategy

Tell the children that leaves are also important to plants because they take in air through tiny openings called stomata. Display a magnified picture of a leaf showing the labeled stomata.

Question - Convergent

Why are leaves important to plants?

Question - Cognitive-Memory

What are the tiny openings on leaves called?

Teaching Strategy

Give each child a sheet of drawing paper, instruct the children to draw a picture of a leaf showing its stomata.

Teaching Strategy

Fit a two-hole rubber stopper into a flask or narrow-necked jar. Insert a long stemmed leaf in one of the holes and a piece of glass tubing, bent at a right angle, into the other hole. Add water so that the stem of the leaf is below the water level when the stopper is inserted into the neck of the flask. Insert the stopper into the neck of the flask, use paraffin to seal holes. From the glass tubing, suck the air. Air bubbles should appear in the water. As you perform the experiment for the children, identify the air bubbles in the water. Explain to the children that the air bubbles are caused by the air traveling through the stomata in the leaf and being forced into the water.

Question - Cognitive-Memory

Where does air enter a leaf?

Question - Convergent

What is causing the air bubbles in the water?

Teaching Strategy

Coat the leaf in the above experiment with petroleum jelly. Again suck the air through the glass tubing.

Question - Cognitive- Memory

What tiny opening is being blocked by the petroleum jelly?

Question - Convergent

How did I prevent air bubbles from appearing in the water?

Questions - Cognitive-Memory

1. What function do roots perform?
2. What function do stems perform?
3. What function do leaves perform?
4. What are the three parts of a seed?
5. What conditions are necessary for seed germination?
6. What conditions are necessary for continued plant growth?
7. What happens when plants are given too much water?
8. How do plants look when they are not healthy?
9. How do plants look when they are healthy?
10. What important thing must you remember when digging up plants?

The following was the science unit, form B, presented to the experimental group.

Generalization A: Plants that grow from seeds need proper conditions for germination.

Teaching Strategy

Discuss with the children if they have observed their parents or other people start a flower garden or new lawn. Instruct the children to describe what is done in planting seeds. After the discussion, show

a few lima bean seeds next to a young lima bean plant.

Question - Divergent

If this plant was grown from a seed, such as this seed, what do you suppose is inside the seed to make such a plant?

Teaching Strategy

Give each child a peanut. Tell the children to remove the protective pod or "shell." Instruct the children to find as many different parts to the seed as they can. The children may describe what they observe verbally and by drawing a diagram of their observations. After this initial activity, work with the children in identifying the reddish brown seed covering, the two seed halves and the plant embryo. Place other dicotyledonous seeds on display. Instruct the children to examine these seeds for similarities and/or differences in structure. Children may make additional drawings of their observations.

Question - Divergent

From what you have observed, what do you suppose the lima bean seed looks like inside?

Teaching Strategy

In response to the above question, have the children make a drawing of their inferences and identify the structures.

Question - Evaluative

Why would you think that all seeds have or do not have the same parts?

Teaching Strategy

Review with the children their observations of people planting a garden.

Question - Evaluative

Why do you think people plant flower seeds in the spring?

Question - Convergent

What is winter weather like compared to spring?

Question - Divergent

What might be some conditions necessary for seeds to grow?

Questions - Evaluative

1. Why do you believe the conditions you mentioned are important?
2. Do you think seeds need soil to sprout? Why do you think so?

Questions - Divergent

1. What might happen if you forgot to water your seeds? What would they look like?
2. What might happen if you gave your seeds too much water? What would they look like?
3. What might happen if you planted some lima bean seeds in the desert?, the artic?, on the moon?

Question - Evaluative

Why do you think those things would happen?

Teaching Strategy

Instruct a child to write the childrens' responses to the above questions on chart paper for the purpose of clarifying or refining hypotheses after experimentation has been made.

Questions - Evaluative

1. What do you think are important things to know about the desert to help us set-up an experiment to see if lima beans could grow in the desert? Why do you think so?
2. What do you think are important things to know about the artic

to help us set-up an experiment to see if lima beans could grow in the artic?

3. What do you think are important things to know about the moon to help us set-up an experiment to see if lima beans could grow on the moon?

Question - Cognitive-Memory

Where could we go to find information?

Teaching Strategy

Have the children gather books, magazines, filmstrips, etc., about the desert, artic and the moon. Divide the children into three committees. Instruct each committee to list information, using the resource material, they believe would be important facts to know if they were going to set/up an experiment to see if lima beans could grow in one of the mentioned areas. Each committee should be assigned one area. After the above activity, have each committee report their information to the group.

Question - Evaluative

Do you think the information this committee reported is important to know in helping us set/up an experiment to find out if lima beans could grow in their area? Why do you think so?

Teaching Strategy

Display some paper towels, several drinking cups, half-pint milk cartons with the tops removed, soil, sand, gravel, and a large glass jar with a screw on top. Review with the children their recorded responses on the chart paper, and the information reported in the above activity.

Question - Divergent

1. How could we use these materials to find out if lima beans could grow in the desert?
2. How could we use these materials to find out if lima beans could grow in the artic?
3. How could we use these materials to find out if lima beans could grow on the moon?
4. How could we use these materials to find out what would happen if lima bean seeds are given too much water?
5. How could we use these materials to find out if lima bean seeds can sprout without soil?

Teaching Strategy

Invite open-end experiments with other kinds of germinating seeds under the conditions established by the children.

Teaching Strategy

Once basic plans have been established by the children as to the purpose and procedure for the experiments, divide the children into small groups. Each group will be responsible for a given set of experiments. Instruct the children in how to construct a growth-rate chart on seed germination for a given condition. After a week or so, draw the groups together to report their findings. Have the children compare their growth rate charts with a graph showing the normal seed germination rate under proper conditions. Help the children to develop some tentative conclusions from their experiments about conditions necessary for seed germination.

Question - Evaluative

Which of these conditions, air, water, temperature, soil, do you think

are important or unimportant to seed germination? Why do you think so?

Teaching Strategy

Present to the children unorganized information consisting of water given per day, soil type, and degree of temperature for a lima bean plant. Instruct the children to produce a bar graph showing the plants probable growth rate.

Teaching Strategy

Instruct the children to describe a frisky dog.

Question - Divergent

What would happen if people as well as animals could not get their energy from food?

Teaching Strategy

Display some germinating seeds on a wet paper towel. Have the children discuss their observations. Point out the plant embryo and tap root.

Question - Divergent

Where do you think the seed is getting its food to grow?

Question - Evaluative

Why are these seeds able to sprout without soil?

Question - Cognitive Memory

What do you see which may offer a clue as to where seeds get their food? (Point out the shriveling seed halves, if no one mentions it.)

Question - Divergent

What do you think may be causing the seed halves to shrivel?

Question - Evaluative

Why do you think so?

Question - Divergent

What ways might we find out if the shrinking seed halve has something to do with where the plant embryo gets its food?

Teaching Strategy

Work with the children in planning experiments to find out what will happen to seed germination when a) both cotyledons are removed from the plant embryo, b) one cotyledon is removed from the plant embryo, c) no cotyledons are removed from the plant embryo. Place all the seeds under a large, inverted cardboard carton to prevent photosynthesis.

Question - Evaluative

Why are we placing our seeds under a cardboard carton?

Question - Divergent

What might happen to our seeds if they were not put under a cardboard carton?

Question - Convergent

How could you find out?

Teaching Strategy

Have the children duplicate the experiment without the cardboard carton. After a week, compare the rate of plant embryo growth for each group of seeds. Discuss with the children how light may have affected the experiment. Discuss with the children the purpose of the experiment and the variables being tested.

Question - Cognitive-Memory

Which plant embryo is growing the best?

Question - Evaluative

Why do you think it is growing the best?

Teaching Strategy

Display a group of radish seeds next to a group of lima bean seeds. Have the children discuss their observations.

Question - Divergent

If the seed halves contain food for growth, do you think these two kinds of seeds contain the same amount of food?

Question - Evaluative

Why do you think so?

Question - Cognitive-Memory

Where does a seed get the energy it needs to push up to the surface and help it grow for the first few weeks?

Question - Evaluative

Do you think it is important or unimportant to know how deep to plant seeds? Why do you think so?

Question - Divergent

What would happen if we planted the radish seed very deep in the ground?

Teaching Strategy

Have the children plant radish seeds and lima bean seeds at various depths in the soil, water each group of seeds as usual. Discuss with the children the purpose of the experiment, that is, what variable they are testing.

Question - Evaluative

Why do we water each group of seeds the same amount of water?

Teaching Strategy

After two weeks, draw the group together to discuss the results of the above experiments.

Question - Convergent

What do you notice about the size of the radish seed and the depth of planting?

Questions - Evaluative

1. What do you think is important to know about the seeds you plant?
   Why do you think so?
2. If you were going to write instructions for planting carrots, what do you think would be important to know about carrots?
   Why do you think so?

Teaching Strategy

Have the children write planting instructions for carrot seeds. Have them compare the information they give with the planting instructions given on a package of carrot seeds.

Generalization B: For proper growth, green plants need light, proper temperature and water.

Teaching Strategy

Review with the children the conditions that they found were necessary for seed germination.

Question - Evaluative

Are all of these conditions necessary for continued plant growth?
Why do you think so?

Question - Divergent

If plants need water, how much water do you think is enough?

Teaching Strategy

Instruct the children to plan experiments to determine the effects of varying a plant's water supply.

Questions- Divergent

1. What do you think will happen if a lima bean plant receives only a small amount of water each day?
2. What do you think will happen if a lima bean plant receives only polluted water each day?
3. What do you think will happen if a lima bean plant received a large amount of water each day?

Teaching Strategy

Instruct a child to record the group's hypotheses on chart paper in response to the above questions. In a week or so after experiments have been conducted by the children to test their hypotheses, instruct the children to remove the plants from their containers and closely examine the plants' roots, stems and leaves. After a discussion of their observations, review with them the responses they had made previous to conducting the experiments.

Questions - Evaluative

1. Do you think it is better to give a plant too much water or not enough water? Why do you think so?
2. Do you think it is better to give a plant polluted water rather than not enough water? Why do you think so?
3. Do you think the results of our experiments supported what we thought would happen? Why do you think so?

Teaching Strategy

Discuss with the children their previous experiences with sprouting

lima bean seeds under an inverted cardboard box.

Question - Convergent

Why did our seeds sprout just as well for a time in the dark as in the sunlight?

Question - Cognitive Memory

What happened to the seeds sprouting in the dark after a while?

Question - Convergent

Why did that happen?

Question - Evaluative

Which group of seeds do you think sprouted the best, after a while? Why do you think so?

Question - Convergent

How do you explain why the one group of seeds grew better?

Question - Divergent

If the plant embryo used the sunlight to help it grow after it used most of its food, do you think the plant will continue to need sunlight? In what ways might you show others why you said "yes" or "no"?

Teaching Strategy

Instruct the children to plan experiments which would test their hypothesis. Discuss with the children the purpose of the experiments.

Questions - Evaluative

1. What do you think you will need to do different to each plant? Why do you think so?
2. What do you think you will need to do that is the same to each plant? Why do you think so?

Teaching Strategy

After about a week, have the children examine the plants. Discuss with the children how sunlight affects plant growth.

Question - Evaluative

If some of our friends wanted to see is plants grow better in the sunlight than in the dark, what do you think would be important information to give them in helping them to do the same experiments we just did?

Teaching Strategy

Have the children take turns recording the group's responses on chart paper.

Questions - Evaluative

1. Do you think the kind of light a plant gets is important to its growth? Why do you think so?
2. We have found out that too much water will hurt a plant, do you think that it is important or unimportant how much light a plant gets? Why do you think so?

Question - Cognitive Memory

What are some sources of light?

Question - Evaluative

Which kind of light, sunlight or indoor light, do you think is best for growing plants? Why do you think so?

Question - Convergent

How could we find out?

Teaching Strategy

Work with the children in planning experiments which will test the

effects of sunlight on plant growth and indoor lighting on plant growth.

Question - Evaluative

Is it important to make sure one of our plants is not getting sunlight? Why do you think so?

Question - Divergent

What ways might you make sure that one plant is only getting indoor light?

Question - Evaluative

Why would we or wouldn't we water both plants as usual?

Teaching Strategy

After the above experiment has been established, work with the children in planning additional experiments to test the effects of the amount of light a lima bean plant receives.

Question - Divergent

Suppose we did not have night and it was day time all the time, what might our plants look like then?

Question - Evaluative

Do you think a plant will grow better if it has light all the time? Why do you think so?

Question - Convergent

How can we find out?

Teaching Strategy

Work with the children in planning experiments which will test the effects of a constant light source on plant growth in comparison to the normal amount of light a plant receives during the course of a day.

Question - Divergent

What ways might you use to show what will happen to a plant that gets light twenty-four hours a day?

Question - Evaluative

Is it important or unimportant to remember to turn off the lights for our other plant when we go home? Why do you think so?

Teaching Strategy

After several days, have children examine both plants. Discuss with the children how the amount of light a plant receives influences its growth.

Teaching Strategy

Review with the children the conditions that they found were necessary for seed germination.

Question - Evaluative

Why would a farmer worry about the weather after his plants have grown in the late summer?

Teaching Strategy

Display a picture of a person covering his plants with plastic bags.

Question - Cognitive-Memory

What is the person doing in the picture?

Question - Evaluative

Why is the person covering his plants?

Teaching Strategy

If the children are unable to reason the answer, have them read the planting instructions for lima bean seeds.

Question - Cognitive-Memory

What time of year is recommended for planting lima bean seeds.

Question - Evaluative

Is it important or unimportant that this information is given? Why do you think so?

Question - Divergent

What ways might we find out if it makes a difference what time of the year a farmer plants his lima bean seeds?

Teaching Strategy

Work with the children in planning experiments to test the effects of cold temperatures upon continued plant growth.

Question - Evaluative

If we put one of our lima bean plants in the refrigerator to see if cold temperatures effect plant growth, what things do you think are important to do for that plant? Why do you think so?

Question - Cognitive-Memory

What is the purpose of our experiment?

Question - Evaluative

A refrigerator has a light bulb that goes off when we shut the door, do you think this information is important or unimportant to know? Why do you think so?

Question - Divergent

What ways might you devise to make sure that the plant in the refrigerator got the proper amount of light it needs?

Teaching Strategy

Encourage the children to think of other ways they might show how cold temperatures influence plant growth. Have the children plan

and construct experiments testing this variable.

Generalization C: Several parts of a plant function in spiecial ways to keep the plant alive and growing.

Teaching Strategy

Ask the children to name several parts of most green plants. Display a lima bean plant, and instruct the children to identify its structure. Instruct the children to identify similar structures in beet, carrot and radish plants. Discuss with the children the relationship of their structure to how they are positioned in the soil. Display a lima bean sprout, and instruct the children to examine the tap root with a magnifying glass. Have the children identify the root hairs.

Question - Evaluative

Many gardeners have trouble when they dig up plants and replant them somewhere else. Even if the gardeners water the plants carefully, give them plenty of light and the right temperature the plants do poorly, sometimes they die. Why?

Question - Convergent

How are roots important to a plant?

Teaching Strategy

Display three closely matched, vigorous bean seedlings growing in separate containers, aluminum foil, a large tray or pan and a hand sprinkler. Challenge the children to think of an experiment, using the materials given, which would help determine the function of the root structure of a plant. Instruct a child to sprinkle water on top of the plant.

Question - Cognitive-Memory

Where does the water fall before it soaks the ground?

Question - Divergent

If you were given these materials, what are some experiments you could set-up to find out if roots are really needed for water absorbtion?

Question - Evaluative

Which part of a plant, the leaves or roots, do you think is better equipped to absorb water? Why do you think so?

Teaching Strategy

Have the children construct experiments which will test the effects of watering a plant only at the roots and only at its leaves. After several days, instruct the children to examine the condition of the two plants. Discuss how roots function in helping the plant grow, and stay healthy.

Question - Convergent

Why is it a good idea to be careful when digging up plants?

Question - Divergent

What would happen if we pulled off some of the roots on a plant and replant them?

Question - Evaluative

Why do you think so?

Teaching Strategy

Display two bean plants and instruct the children to think of an experiment which would help them find out how the destruction of a plant's root structure affects plant growth. Display a picture of the root system of a willow tree.

Question - Convergent

How is a willow tree like a lima bean plant?

Teaching Strategy

Display a picture of a tree with a root system that is not as extensive as the willow tree's root system.

Question - Evaluative

Which tree would you prefer to plant in your yard? Why?

Question - Divergent

If you were "Mother Nature", how would you help lima beans survive in the desert?

Question - Evaluative

Why would you or wouldn't you worry about weeds in your garden?

Teaching Strategy

Tell the children that florist often color their white carnations green for St. Patrick's Day. Display a green carnation.

Question - Divergent

How do you suppose this is done?

Teaching Strategy

Invite the children to make a colored carnation. Challenge the children to make a two colored carnation. Give the children several days for this activity, before asking the following questions.

Question - Convergent

How is water transported from the roots to the leaves?

Teaching Strategy

Display a stalk of celery, a container of water and some food dye.

Question - Divergent

If you were given these materials, in what ways might you show how the leaves of a plant get water?

Teaching Strategy

After the celery has been immersed in the colored water for a few minutes in strong sunlight, instruct the children to examine the spidery network of colored lines by pulling apart the stalk of the celery and exposing the individual tubes. Discuss with the children the functions plant stems play in maintaining the health of a plant.

Teaching Strategy

Display a lima bean plant.

Question - Divergent

What do you think would happen if we removed the leaves from this plant?

Question - Evaluative

Why do you think that would happen?

Teaching Strategy

Instruct the children to plan an experiment which would test the affects of removing a plant's leaves upon the plant's growth and health.

Teaching Strategy

Instruct the children to observe a leaf under a microscope, or display a diagram of an enlarged leaf. Have the children discuss their observations. Identify the leaf openings or stomata.

Question - Divergent

Why do you suppose a leaf would have these openings?

Teaching Strategy

Fit a flask or narrow-necked jar with a two-hole rubber stopper. In-

sert, in one of the holes, a leaf with a long stem. Insert in the other hole a piece of glass tubing or a plastic soda straw ben at an angle. Add water to the flask so that the stem of the leaf is below the level of the water when the rubber stopper is inserted into the neck of the flask. Paraffin may be used to seal the holes.

Question - Divergent

What do you think will happen if you were to suck air from the soda straw?

Question - Evaluative

Why do you think so?

Teaching Strategy

Instruct a child to suck air from the soda straw. Air bubbles should appear in the water. Discuss with the children their observations.

Question - Divergent

From where do you suppose the air bubbles are coming?

Question - Evaluative

Sometimes you see people "dusting" their plants. Do you think they are being silly? Why do you think so?

Question - Divergent

In what ways might you prevent air bubbles appearing in the water when you suck through the soda straw?

Teaching Strategy

Have the children identify were the majority of stomata are located on a leaf.

Question - Evaluative

Do you think it is important or unimportant where the stomata are

located on a leaf? Why do you think so?

Question - Divergent

What do you suppose would happen if the stomata were clogged on a plant leave?

Question - Evaluative

Why do you think so?

Teaching Strategy

Instruct the children to plan an experiment which would test effects of clogging the stomata on a plant's leaves. Discuss the results of the experiment as to the function leaves play in plant growth and health.

Teaching Strategy

Display a picture of a pond of water lily leaves.

Question - Divergent

Which side of the water lily leaves would you probably find stomata?

Question - Evaluative

Why do you think so?

Teaching Strategy

Instruct the children to plan a garden for the school.

Question - Evaluative

Where is the best location for a school garden? Why do you think so?

Teaching Strategy

Take the children to a garden store, or any store where garden seeds are sold.

Question - Evaluative

Which kind of seeds will you plant in your garden? Why?

Instruct the children to plant their seeds in the school yard. Alternate groups of children to maintain the garden to insure plant growth and health. After several of the plants have reached maturity, instruct the children to replant them in containers. Instruct the children to write a story about their plants. The stories may include the name of the plant, the method for planting its seeds, and how the plant should be cared for to insure a healthy specimen.

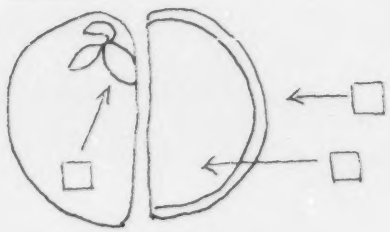
Proposed Methods of Collecting Data

The proposed methods for collecting data was the administration of the following teacher-made tests to both treatment groups.

Pre-Test:

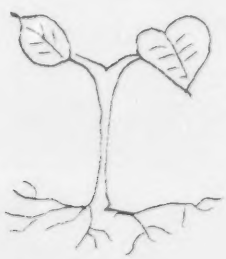
Knowledge

1. Write a letter in each box that names the correct part of the picture.



   A. plant food
   B. tap root
   C. seed coat
   D. plant embryo

2. Label the parts of this plant.



Comprehension

3. Pretend you have planted a lima bean plant under a large tree and you forgot to water your plant. Draw and color a picture of what your plant will look like.

4. A friend wants to plant some carrots. Underline the sentence that tells what he should do first.

   A. He should spray bug poison on the ground.

   B. He should dig up the ground with a shovel.

   C. He should find a sunny place.

   D. He should sprinkle plant food on the ground.

Application

5. While your friend's carrots are growing, he goes on a vacation and asks you to take care of his carrot garden. What things will you do to take care of his garden?

6. Your friend also wants you to take care of his house plants. How will you take care of his plants?

Analysis

7. While you are caring for your friend's house plants, you notice that some of the leaves are turning brown and falling off the plants. Underline the sentence that is not a reason for causing the leaves to die.

   A. The plants need water.

   B. The plants are getting too much light.

   C. It is very cold outside.

   D. The room is very dusty.

   E. It is very cold in the room.

   F. The blinds are closed in the room.

8. If you were going to plant some tomatoe seeds, underline the sentence(s) which would be helpful information to know.

   A. The weatherman states that the weather will be very cool and dry for the next few months.

   B. The tomatoe seeds were bought last winter.

   C. Your garden contains a lot of sand.

   D. Tomatoe seeds should be planted one inch deep.

   E. The tomatoe seeds were found in a seed package marked "Carrots."

Synthesis

9. How might you show your friend that a plant needs only a certain amount of water each day?

10. Pretend you have traded your candy for a magic seeds. Draw and color two pictures. In the first picture, show the inside of your seed; in the second picture, show your seed as a grown plant.

Evaluation

11. Suppose you lived on Mars and wanted to plant a vegetable garden. What do you feel would be important information to know about the place were you lived? Why?

Post-Test

Knowledge

1. Name the three parts of a seed.

2. Name the three parts of a green plant.

Comprehension

3. Pretend you have planted a vegetable garden in November and the next day it begins to snow. Draw and color a picture of what your garden will look like in a few weeks.

4. You are going to plant a flower garden. Underline the sentence which tells you what you should do first.

   A. Remove all the weeds from the garden.

   B. Find a sunny place.

   C. Read the planting directions.

   D. Spray bug poison on your garden.

   E. Water the garden.

Application

5. Pretend you have planted a garden of onions, what things will you do to take care of your garden?

6. Your mother has given you the job of taking care of the house plants. How will you take care of them?

Analysis

7. While you are caring for the house plants, you notice that some of the leaves are turning brown and falling off the plants. Underline the sentence(s) which would cause the leaves to die.

   A. The plants are getting too much light.

   B. It is very cold outside.

   C. The room is very dusty.

   D. The plants are near the heat register.

   E. It is autumn.

8. If you were going to plant some radish seeds, underline the sentence(s) which would be helpful information to know.

   A. The radish seeds were found in a seed package marked "Tomatoes."

   B. The weatherman states that the weather will be very dry and cold for the next two months.

C. Your garden contains a lot of sand.

D. Your radish seeds should be planted one inch deep.

E. Your friend bought the radish seeds last winter.

Synthesis

9. How might you show your friend that a plant needs light in order to stay healthy?

10. Pretend you have traded your candy for some magic seeds. Write a short story describing the planting instructions you read on the seed package.

Evaluation

11. Suppose you moved to a strange new planet and you wanted to plant a vegetable garden for food. What do you feel would be important information to know about the place were you live?. Why?

CHAPTER III

FINDINGS

Comparison of Means

The findings of this study indicated no significant differences in the type of questioning strategies a teacher provides for his/her students relative to the given unit of study, and student performance at higher cognitive levels of Bloom's Taxonomy of Educational Objectives.

The results of the t-test for the pre- and post-tests is presented in Table 1. The control group had slightly higher mean scores on the pre- and post-tests than the experimental group, but all differences were not significant.

TABLE 1. RESULTS OF SIGNIFICANCE TEST FOR PRE- AND POST-TESTS AND CHANGE IN MEANS

	Pre-Test	Post-Test	$\Delta \bar{X}$
Control $\bar{X}$	20.7	37.07	16.37
Experimental $\bar{X}$	21.3	36.87	15.57
"t" *	.071	.214	.143

* Required for .05 level, 2.04

Test Item Analysis

The percentage of change of intragroup scores for each question on the pre- and post-tests is presented in Table 2. The analysis shows that the highest percentage change occured, for both groups, at the knowledge level of questions one and two, at the analysis level of question seven, and at

the synthesis level of question nine. A slight percentage change occured, however, at the analysis level of question eight for the control group, with no change occuring for the experimental group. A slight percentage change occured at the evaluation level of question eleven for both groups.

TABLE 2. PERCENT CHANGE OF INTRAGROUP SCORES

	Control Group			Experimental Group		
Paired Question *	Pre-Test	Post-Test	%Δ	Pre-Test	Post-Test	%Δ
1	24	100	+76	13	98	+85
2	62	96	+34	51	89	+38
3	33	51	+18	51	42	-9
4	40	47	+7	53	73	+20
5	44	71	+27	38	68	+30
6	40	60	+20	42	58	+16
7	0	51	+51	7	49	+42
8	51	49	-2	56	56	0
9	11	40	+29	2	34	+32
10	34	51	+17	42	48	+6
11	20	19	-1	26	35	+9

* Questions 1 and 2, knowledge level
Questions 3 and 4, comprehension level
Questions 5 and 6, application level
Questions 7 and 8, snalysic level
Questions 9 and 10, synthesis level
Question 11, evaluation level

A graph analysis of percentage points received by each group for each

number and type of question asked on the pre-test is presented in Figure 1. The graph suggests that the control group performed slightly better than the experimental group on questions one, two (knowledge), and question five (application). The experimental group performed slightly better than the control group on question six (application), questions seven and eight (analysis), question ten (synthesis), and question eleven (evaluation). The greatest variance in scores occured at the comprehension level where the experimental group received the higher percentage points for questions three and four. Generally, the graph shows a close parallel between the percent of points received for each question for each group and the number and types of questions asked on the pre-test.

A graph analysis of percentage points received by both groups for each number and type of question asked on the post-test is presented in Figure 2. The graph shows that both groups scored highly on question one (knowledge) with the control group scoring 100%, and question two (knowledge) with the control group scoring 96%. The greatest variance of percentage scores between both groups occured at the comprehension level of question four where the experimental group received the higher percentage score. However, the control group performed slightly better on question three at the comprehension level than did the experimental group, who scored higher on both questions in this area on the pre-test. The control group performed slightly better on questions five (application), seven (analysis), and questions nine and ten (synthesis) than did the experimental group. Generally, the graph shows a close parallel between percentage scores received for each number and type of question asked for both groups on the post-test with the exception of question four and possibly question eleven.

Figure 1. Percent of Points Received For Each Question For Each Group Compared With The Number And Types Of Questions Asked On A Pre-Test Of Third And Fourth Graders On A Four Week Botany Unit.

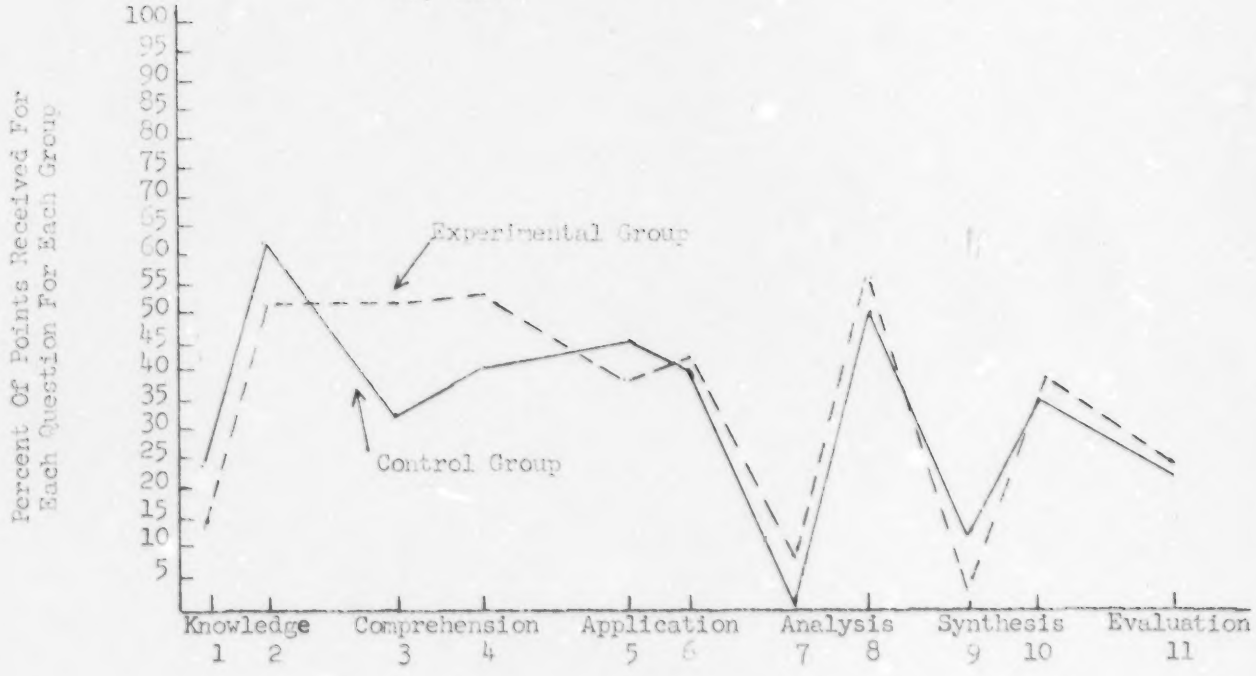
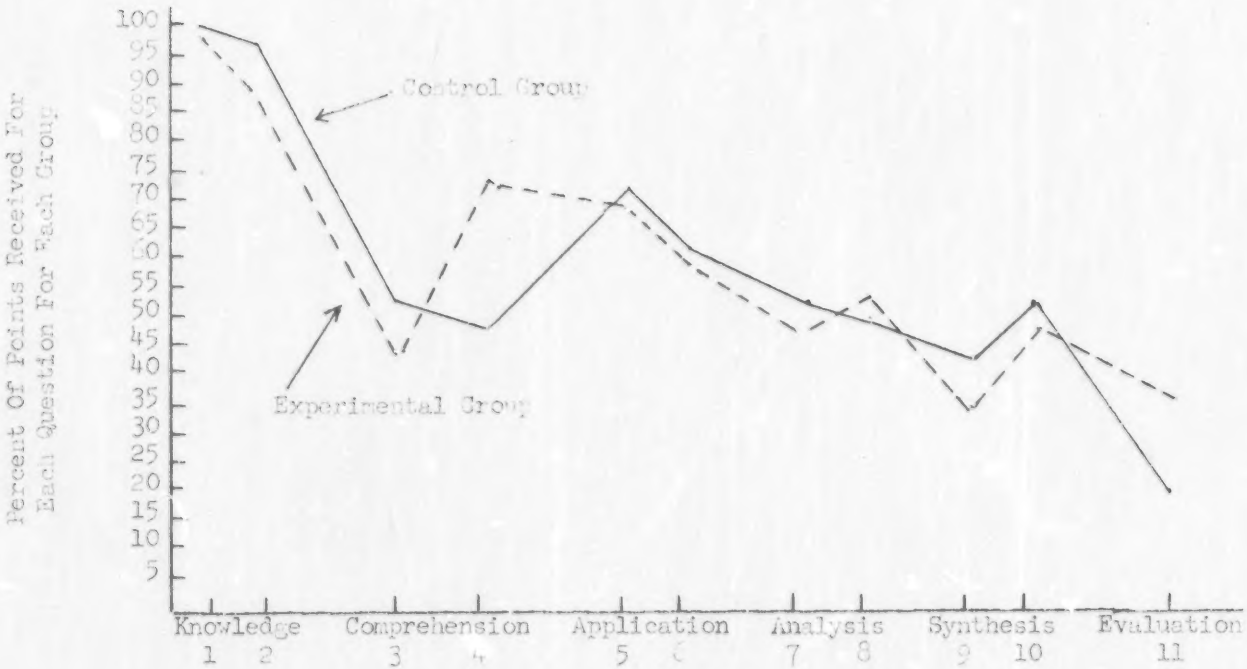


Figure 2. Percent Of Points Received For Each Question For Each Group Compared With The Number And Types Of Questions Asked On A Post-Test Of Third And Fourth Graders On A Four Week Botany Unit.



Number And Types Of Questions Asked On A Post-Test Of Thirty Third And Fourth Graders On A Four Week Botany Unit

CHAPTER IV

INTERPRETATION OF FINDINGS

Conclusion

In order for children to develop critical thinking skills, the relationship between the kinds of questions a teacher asks in setting the tone of cognition in the classroom and student performance above the knowledge level as defined by Bloom's Taxonomy of Educational Objectives needs to be analyzed.

In a effort to explore this relationship, a botany unit was studied by two groups (fifteen per group) of third and fourth graders. Instruction in the control group centered on the use of cognitive memory questions. Dominant emphasis of instruction in the experimental group centered on the use of cognitive level questions above the stage of recall. Both groups were compared with regard to the degree of change occuring in the development of critical thinking skills. The comparison was based upon applying a *t*-test to mean group scores received on teacher made pre- and post-tests reflecting the six levels of Bloom's Taxonomy of Educational Objectives, no statistically significant differences were found. Intragroup scores and percent of points received by each group for each test item on the pre- and post-tests were also analyzed.

Although pre-test scored revealed a close parallel of percentage points received for each question by both groups, it was noted that a wide variance of scores occured by both groups between questions at a particular cognitive level. At the knowledge level, both groups scored below the 25% level on the first question in contrast to the second question in which both groups scored above the 50% level. This variance may be the result of knowledge

retention of a prior introduction to a botany study in the earlier grades in which particular emphasis may have been placed on the anatomy of a green plant rather than the parts of its seed.

Also noted was the wide variance of percentage scores received by both groups on the pre-test at the analysis level (questions seven and eight), and at the synthesis level (questions nine and ten). It was noticed that during the administration of the pre-test, by the writer, the experimental group seemed confused as to what was meant by selecting a negative response in question seven. However, little difficulty seemed to exist in selecting the positive responses required in question eight. In light of the slight variance which occured at the same level between questions seven and eight by both groups on the post-test in which the questions required positive responses, and assuming that a similar confusion also existed within the control group on the pre-test question seven, it would than seem that a contributing factor to the wide variance between questions seven and eight on the pre-test by both groups may have been due to the manner in which these questions where phrased. It would seem that phrasing analysis questions so as to require a negative response may be more difficult for children to respond to than similar cognitive level questions requiring positive responses. Furthermore, lack of experience in selecting responses which do not belong to a given set of statements may have also contributed to the wide variance noted.

The wide spread of percentage scores on the pre-test between questions nine and ten (synthesis level) by both groups may have been due to the manner of response required when compared with questions nine and ten at the same level on the post-test. It would appear that lack of experience in trans-

Latin thought to a written form at the synthesis level was greater than translating thought at the same cognitive level to a pictorial form. Furthermore, it was noted that this difficulty continued to exist at the synthesis level after instruction for both groups. It would seem that the tests given (pre and post) did not allow for the lack of ability/... experience in translating critical thinking at this level to the written form, and that the development of this ability in the experimental group was not given sufficient time or due consideration.

These factors may have also influenced post-test results which showed a parallel decline in percentage scores received by both groups as they progressed to the higher cognitive levels. Furthermore, the use of essay questions (post-test items five, six, nine, ten and eleven) may not have been a suitable means of assessing the development of critical thinking because of its low reliability as a formal evaluation technique. Anderson states:

> The validity of essay tests is open to question because of the low reliability as well as the fact that the person grading the essay may be unduly influenced by how well the ideas are presented rather than what the ideas are. (1, p. 178.)

However it must be concluded from the findings that, the extent to which the teacher-made post-test represented the six levels of Bloom's Taxonomy of Educational Objectives, the null hypothesis must be accepted. That is, pupils given instruction emphasizing the use of questions predominantly above the knowledge level did not differ significantly with respect to critical thinking from pupils given instruction predominantly based on knowledge questions.

Summary

To say that instruction which emphasizes questioning strategies at the higher levels of the cognitive domain does not stimulate critical thinking is not a simple conclusion. The rational of such a conclusion may necessarily be complex.

Piaget's position with regard to the cognitive development of children generally indicates that all children progress through certain stages of intellectual development, and progress from stage to stage is the same for every child. Thus, the extent to which the null hypothesis is supported may have its strongest explanation in Piaget's conceptualizations. Although, it is realized that progress through the stages is not automatic and the age at which the stages occur can vary with the individual.

If for the purpose of discussion, it is assumed that the cognitive development of the sample population used in the study generally reflected the cognitive behaviors attributed to children at the concrete operational stage, than it would seem that the nature of the questions posed to the experimental group may have been more successful in stimulating critical thinking of children at the formal operational stage of Piaget's schemata. Wadsworth states:

> The concrete operational child must deal with each problem in isolation. Operations are not coordinated. The child cannot integrate his solutions by means of general theories. The child with formal operations can employ theories in the solution of many problems in an integrated manner. Several operations can be brought to bear on a single problem.

In addition, formal operations are characterized by scientific

reasoning, hypothesis building (and testing), and they reflect a true understanding of causation... (11, p. 102.)

It is not being suggested that it is fruitless to stimulate critical thinking in elementary school children via questioning strategies aimed at this purpose, but that methods and questioning strategies based upon Bloom's Taxonomy of Educational Objectives in the study may need to be reoriented to a range of application for logical operations available to the Piaget child with appropriately readjusted objectives and techniques for evaluating critical thinking.

Perhaps critical thinking is an ability, somewhat analogous to intelligence. Just as one does not teach to improve intelligence, one may not necessarily be able to teach how to think critically; one can only hope to improve this ability to some unknown degree. Thus, another possible reason for the findings may have been attributed to the inadequacy of measuring gross critical thinking on the post-test. Also, the findings may have been effected by insufficient time and experiences to foster complex cognitive functions. Therefore, it is recommended that the study be conducted over a longer period of time in which children are provided experiences with high level questions which utilize their abilities in many areas of learning.

In view of the findings, the value of knowledge questions in stimulating thinking should be further investigated. It is recommended that the study be altered in such a way as to ultilize more fully, low level questions before progressing to the higher level questioning strategies. Hunkins states, "Taba (1967) advocated this strategy and had obtained empirical evidence as to its effectiveness. (7, p. 703.)

Teacher experience in using questioning techniques for lifting levels of thought, expanding and using learners' ideas also play a part in the cognitive development of children. Lack of prior experience in employing comprehensive questioning patterns which search to raise thinking above the factual recall level may have reduced the effectiveness of such questions in stimulating critical thinking. It is therefore recommended that an instructional program be designed specifically to improve a teacher's ability in employing the levels of questioning strategies in the various curriculum areas of education.

The role by which the levels of questioning affect student performance above the knowledge level is still imprecise. The results of the study forestall the simple conclusion that if the teacher asks high level questions, pupils will think critically. At this point, additional research is an essential condition for the advancement of more conclusive evidence.

BIBLIOGRAPHY

1. Anderson, Ronald D., "Developing A Competency For Evaluation," in Developing Teacher Competencies, pp. 166-206, New Jersey: Prentice-Hall, Inc., 1971.

2. Bloom, Benjamin S. (ed.), Taxonomy of Educational Objectives. Handbook I: Cognitive Domain, New York: David McKay, 1967.

3. Crump, Claudia, "Teachers, Questions, and Cognition," Educational Leadership, 27:657-660, April, 1970.

4. Cunningham, Robert T., "Developing Question-Asking Skills," in Developing Teacher Competencies, pp. 81-130, New Jersey: Prentice-Hall, Inc., 1971

5. Doak, Dale E., "Evaluating Levels of Thinking," School and Society, 98:177-178, March, 1970.

6. Gega, Peter C., Science in Elementary Education, New York: John Wiley and Sons, Inc., 1966.

7. Hunkins, Francis P., "Analysis and Evaluation Questions: Their Effects Upon Critical Thinking," Educational Leadership, 3:697-705, April, 1970.

8. Sanders, Norris M., Classroom Questions - What Kinds? New York: Harper and Row, Publishers, 1966.

9. Taba, Hilda, Teachers' Handbook for Elementary Social Studies, California: Addison-Wesley, Publishers, 1967.

10. Victor, Edward, Science for The Elementary School (2nd. ed.), New York: The MacMillan Company, 1970.

11. Wadsworth, Barry J., Piaget's Theory of Cognitive Development, New York: David McKay Company, Inc., 1971.

APPENDIX A

Raw Test Scores
Pre-Test

Pair No.	Control Group	Experimental Group
1	34	27
2	25	14
3	31	18
4	12	30
5	21	20
6	8	21
7	13	10
8	12	23
9	32	12
10	20	26
11	23	22
12	28	25
13	21	36
14	8	23
15	22	12

APPENDIX B

Raw Test Scores
Post-Test

Pair No.	Control Group	Experimental Group
1	48	43
2	49	42
3	38	38
4	29	42
5	20	43
6	28	25
7	32	25
8	36	39
9	45	25
10	37	37
11	50	31
12	55	38
13	24	55
14	19	37
15	46	33